# CAUSES OF STRAIN BIREFRINGENCE AROUND THE NOTCHES IN MOLDAVITES

H. H. Majmundar†

and

J. A. O'Keefe
Theoretical Division
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland

## ABSTRACT

Internal strain birefringence patterns in nine specimens of Moldavites were studied between crossed polaroids and it was found that the strain patterns are associated using a grinding wheel. Around these artificially produced notches also, there were the strain concentrations. Then one of the specimens was carefully annealed by heating at 1000° C for four days and then quenched by an air blast. The finally produced pattern was similar to the original pattern. By this experiment, it is clear that concentration of the general strain is the result of the cooling of tektite; however, the presence of pattern does not tell whether the grooves were formed before or after the cooling of the tektite.



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The notches and grooves which appear on the outside of tektites have been the subject of study for the last 65 years (Suess, 1900). Two principal theories of their origin have been proposed:

(a) Carving by aerodynamic forces;

(b) Etching by ground chemicals.

A few years ago Barnes (1961) drew attention to the fact that between crossed polaroids many tektites show a pattern of internal strain. In places the strain appears to be correlated with the notches in the surface in the sense that the strain is more intense around the notches. Barnes (verbal communication) suggested an explanation in terms of more rapid etching in the direction of the strain. Chapman (verbal communication) suggested that the concentration of strain around the notches was a simple consequence of the tendency in any mechanical system for the strain to concentrate around cracks. The possibility also existed that the strain might have been produced by the vortices

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themselves, which Suess considered as responsible for carving the tektites.

Nine tektites (USNM No. 2051, 5 pieces; No. 2052, 1 piece; No. 2053, 3 pieces) were chosen from the large collection at the Smithsonian. They were selected as having conspicuous strain patterns and as having patterns obviously associated with notches. At Goddard, these 9 tektites were photographed between crossed polaroids, and the association of the strain pattern with the notches was recorded (see Figure 1, A and B). It was found that in each case, the tektites had an overall strain pattern as well as one associated with the notches. The strain pattern was the one which would be expected for bodies which were rapidly cooled; that is, the outer portions of the bodies were in compression in a tangential direction, and were in tension in the radial direction. The explanation is presumably that the outside cooled first and formed a rigid envelope. When the inside shrank, it pulled the outer portions inward toward it, thus producing a radial tension; at the same time the outermost portion functioned like an arch, and thus came into tangential compression.

All the nine tektites were now notched in the laboratory of the Optical measurements Branch using a grinding wheel in such a way as to produce notches generally similar in form to those found in the original tektites. The tektites were then examined between crossed polaroids again, and it was found that as predicted by D. R. Chapman, the overall strain of shrinkage had rearranged itself around the notches

in a way indistinguishable from the stress concentrations around the existing tektite notches (see Figure 2, A and B). This result is consistent with the formation of the notches in natural tektites by ground acid attack. Had the notches been formed by some kind of special heating mechanism, it might have been expected (and in fact, it was hoped) that the pattern around the notches would have indicated tension in the tangential direction. This would have been expected, if there had been special heating in the notches after the tektite as a whole had received its final form.

A study was then conducted to see whether it was certain, rather than just possible, that the notches had been cut after the tektite had been cooled. One of the tektites was carefully annealed by heating it for 4 days at $1000^{\circ}$ C in a temco furnace (Thermolyne-Type A 1300). It was then quenched by an air blast. The finally produced pattern was similar to the original pattern (see Figure 3, A. B. and C). It is clear that the presence of the pattern does not tell us whether the grooves were formed before or after the cooling of the tektite. The pattern near the grooves is, however, clearly a local concentration of the general strain which resulted from the cooling of the tektite.

Acknowledgements

Thanks are due to Dr. E. P. Henderson of the Smithsonian for providing the moldavite samples.

References

Barnes, Virgil E., (1961), Tektites, Scientific American, 205, 58-65.

Suess, F. E. (1900), Die Herkunft der Moldavite und werwandter Gläser, Jahrbuch der k. k. Geologische Reichsanstalt, 50, 193-382.

Explanations to the figures

Figure No. 1

Strain birefringence pattern around the notches in moldavites.

(a) Strain pattern around the original notch ;

(b) Specimen rotated $45^{\circ}$ with respect to the polarizor.

Figure No. 2

Strain birefringence pattern around the notches in moldavites.

(a) Original notch in the north. Two artificially produced notches in north-east and in the south. All the three notches show strain pattern around them;

(b) Specimen rotated $45^{\circ}$ with respect to the polarizor.

Figure No. 3

Strain birefringence pattern around the notches in moldavites.

(c) Original sample with strain pattern;

(b) Annealed sample where the strain pattern has disappeared;

(a) Strain pattern produced after quenching.

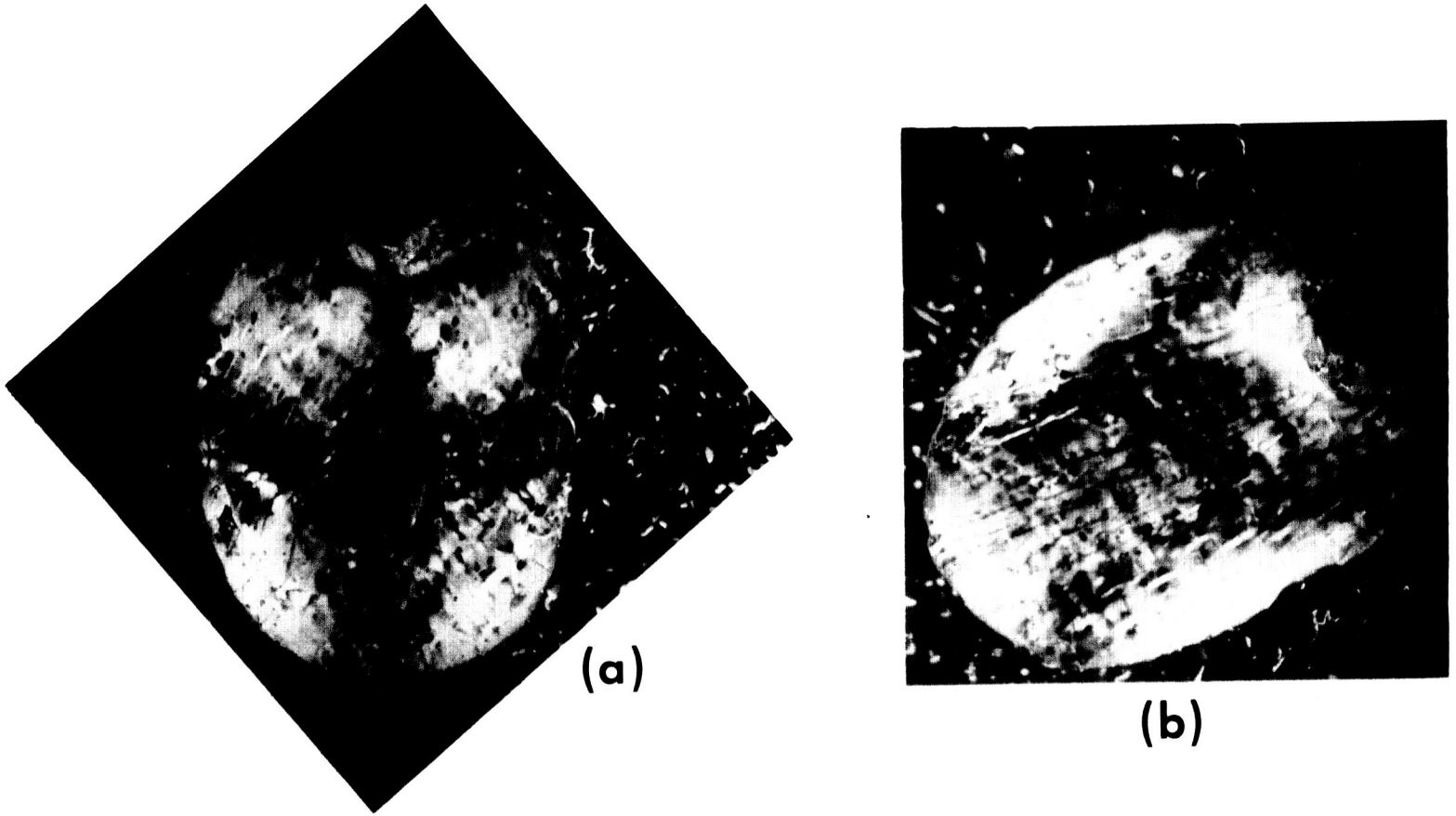
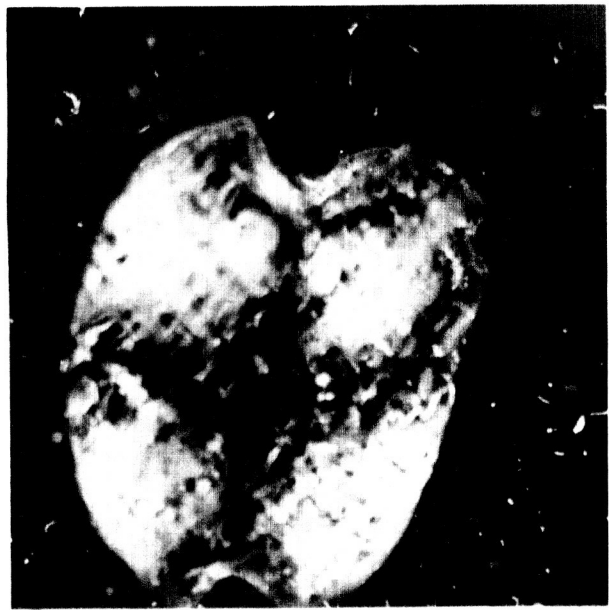


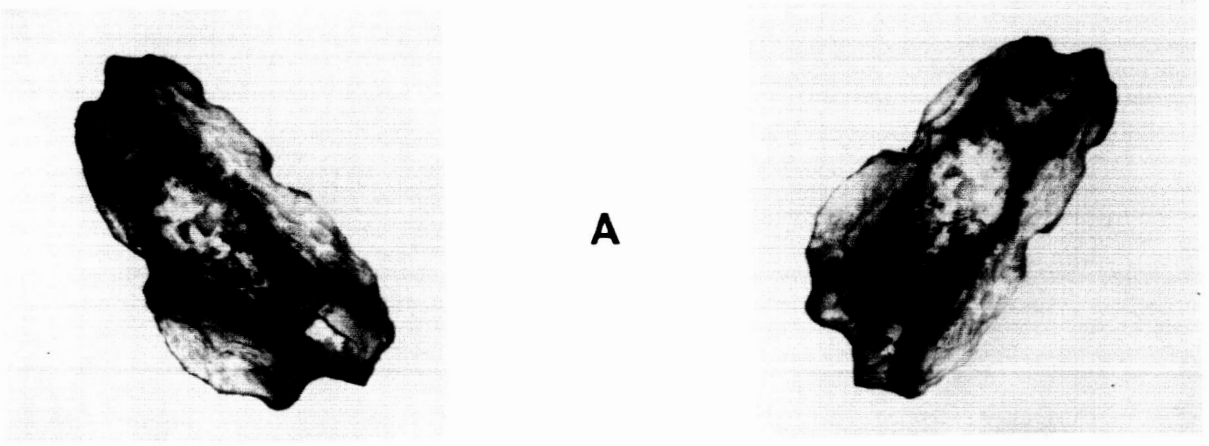

FIGURE - 1



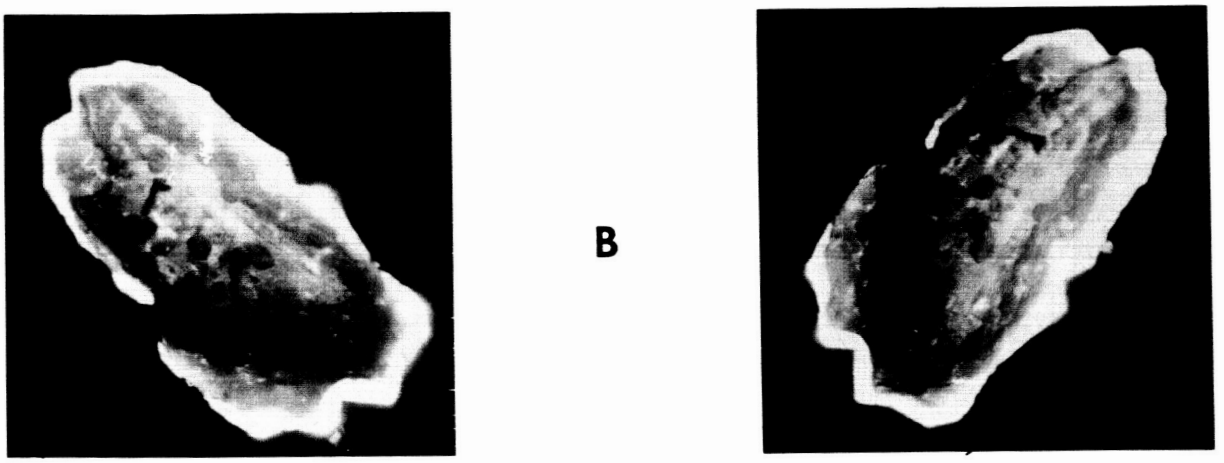
(a)

(b)

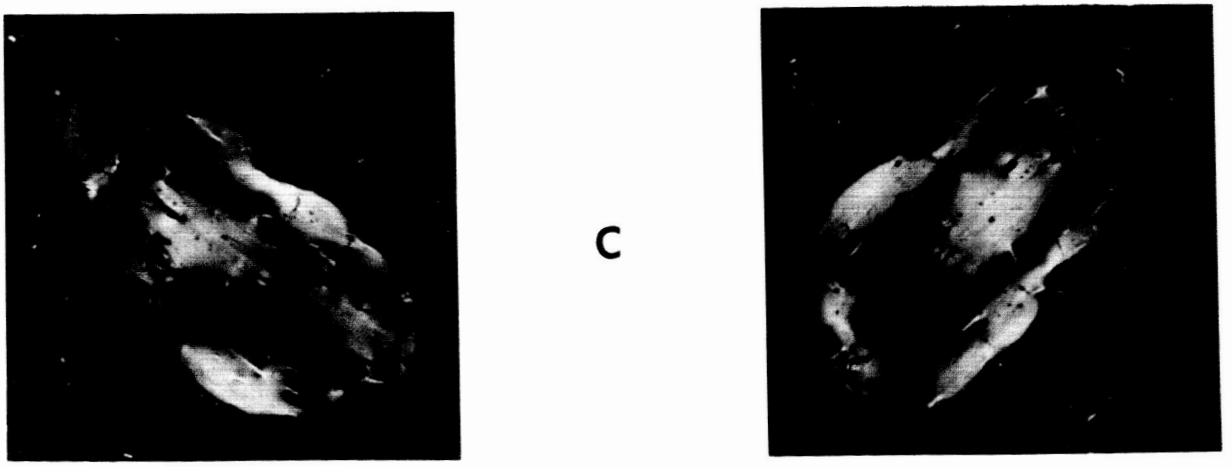
FIGURE - 2



A



B



C

FIGURE - 3